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Studio to cubicle insulation requirements with delayed monitoring

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STUDIO TO CUBICLE INSULATION REQUIREMENTS WITH DELAYED MONITORING

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STUDIO TO CUBICLE INSULATION REQUIREMENTS WITH DELAYED MONITORING

Summary

This report describes experiments made to determine the minimum sound insulation required between a studio and its control cubicle when the sound in the cubicle has been delayed by a tape recorder having separate recording and playback heads. It is found that more insulation is required when a longer monitoring delay (corresponding to a slower tape speed) is introduced. At a tape speed of 19 cm/second and assuming equal sound fields in studio and cubicle, a minimum sound insulation (at 500 Hz) of 51 dB is recommended.

1. Introduction

With monitoring 'off-tape' becoming common operational practice in sound control cubicles, it is likely that additional sound insulation is necessary between the control cubicle and its studio. This would prevent delayed sound coming from the cubicle unduly interfering with or contributing to the sound field in the studio. Such an effect would be highly disturbing to a person speaking in the studio and in a bad case could cause the speaker to stutter. A series of experiments was therefore conducted in order to ascertain the maximum tolerable delayed sound field which was just not perceptible to a person speaking in the studio.

2. Experimental details

In order to simulate the different sound spectra corresponding to the passage of sound through either single or double-wall partitions, it was decided to simulate the sound insulation characteristic by means of an electrical frequency-weighting network placed in circuit between the output of the sound-delaying tape recorder and a power amplifier feeding a loudspeaker placed in the studio. This created in the studio a delayed sound field with frequency-weighting appropriate to sound coming through a typical sound insulating partition. Any desired modification to the sound spectrum which might be thought useful could be simulated by the use of suitable filters.

An omnidirectional microphone was placed at the speaking position in the studio and connected to a calibrated-gain microphone amplifier whose output was measured by an r.m.s. valve-voltmeter. For calibration purposes an octave band of pink noise centred on 235 Hz was recorded at a known level by the sound-delaying tape recorder which was situated in the control cubicle and the noise reproduced via the frequency-weighting network. An attenuator in the studio at the speaking position was set at 0 dB for this calibration. The signal was then passed to the power amplifier feeding the studio loudspeaker and the resulting sound was picked up by the microphone (Fig. 1). The gain of the microphone amplifier was set, using the valve-voltmeter, so that its output was equal to the original level recorded on the tape. Thus the entire system was made to have unity overall gain at 235 Hz.

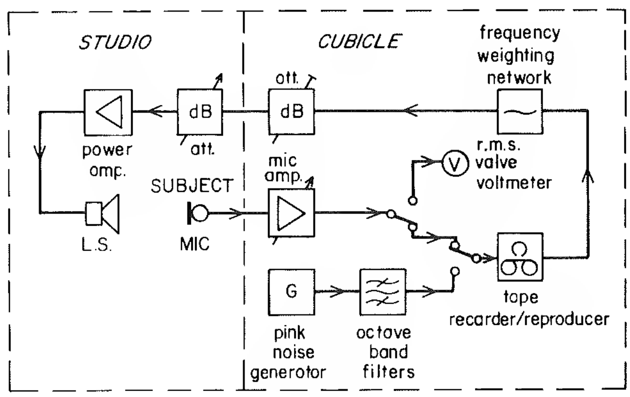


Fig. 1 - Block schematic

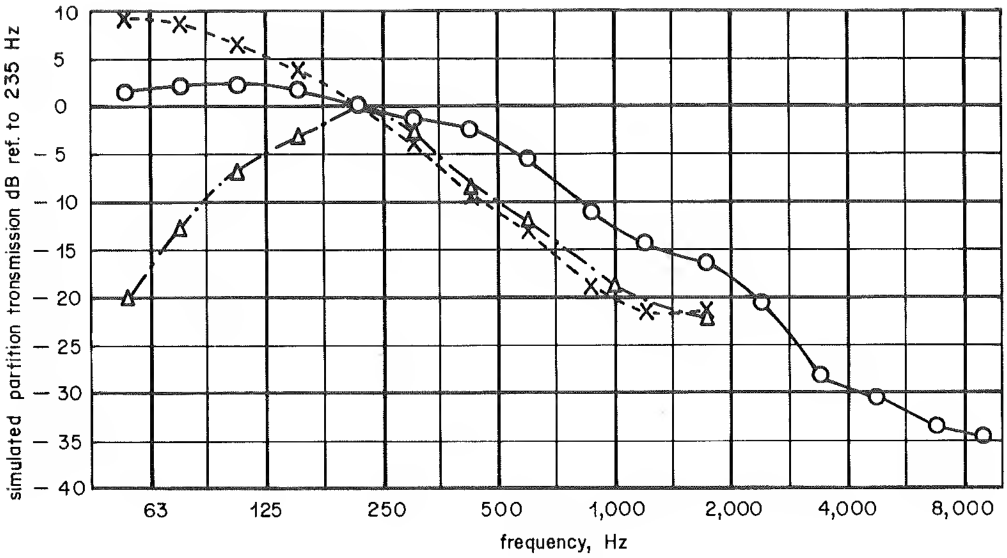


Fig. 2 - Simulated sound partition transmission characteristics

—O— single-wall simulation --X-- double-wall simulation ·—Δ—· double-wall simulation with bass-cut

The gain at other frequencies was determined by the frequency-weighting network used to simulate a single or double-wall partition (Fig. 2).

The attenuator in the studio was operated by the subject who was asked to adjust its value, whilst speaking, until he was just not aware of his delayed speech heard via the loudspeaker. For this purpose the output of the microphone amplifier was connected to the input of the sound delaying tape recorder in the cubicle. The attenuator setting gives the minimum required insulation of the sound partition at 235 Hz, and the insulation required at 500 Hz (a value commonly found to correspond to the insulation averaged over the frequency range 105–3150 Hz) is found by reference to the frequency-weighting network (Fig. 2).

This experiment was performed with 20 subjects and two delays (180 ms and 90 ms) were tested for each subject, corresponding to the 19 cm/sec and the 38 cm/sec tape speeds. Three types of simulated sound partitions were effectively tested: a single-wall partition having a loss increasing at an average rate of 5 dB per octave; a double-wall partition having a loss increasing at an average rate of 10 dB per octave; and an average 10 dB per octave loss together with a progressive bass-cut at frequencies below 235 Hz (Fig. 2).

3. Results

3.1. Results of single-wall simulation

Fig. 3. shows the distribution of the results obtained from 20 observers, using the 5 dB/octave frequency-weighting network (simulating a single-wall partition). The mean value of the attenuation required at 500 Hz was about 42 dB for a tape speed fo 19 cm/second, whilst the value for the shorter delay corresponding to a tape speed of 38 cm/second was some 8 dB less, namely 34 dB. This clearly shows that the longer delay is a considerably more critical condition and will necessitate greater insulation between cubicle and studio. In order to satisfy 19 out of the 20 subjects (assuming equal sound fields in cubicle and studio) some 49 dB of insulation are required at 500 Hz for the longer delay.

3.2. Results of double-wall simulation

As the sound insulating partition between cubicle and studio often consists of a double wall, a 10 dB/octave network was used for the experiments and the results are shown in Fig. 4. The mean value of attenuation required in this condition was slightly higher: 43½ dB for the 19 cm/second tape speed and 36 dB for the 38 cm/second tape speed. An average insulation of 51 dB would satisfy 19 out of 20 subjects at the longer delay.

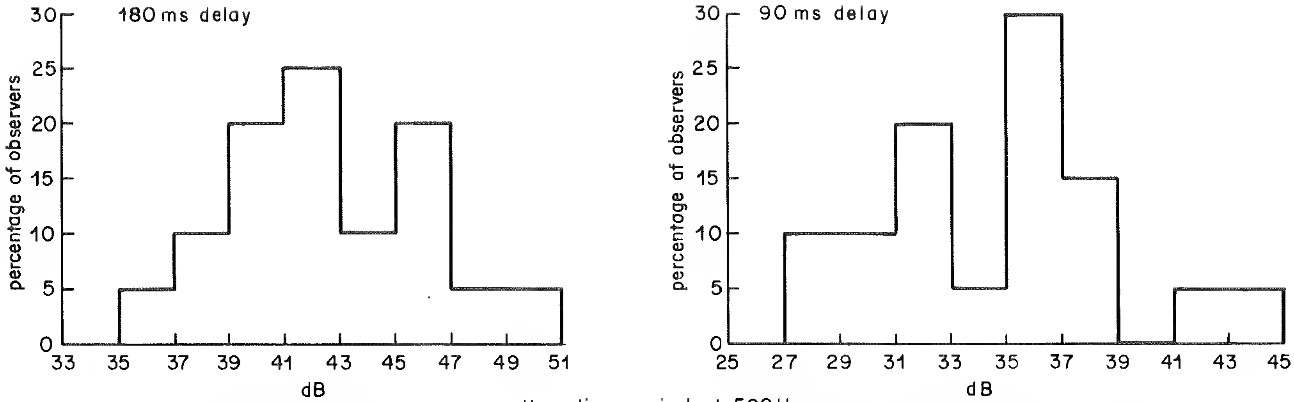
3.3. Double-wall simulation with bass-cut

In this experiment, in addition to the 10 dB/octave low-pass network, a circuit was included which progressively attenuated frequencies below 235 Hz (Fig. 2.), thus removing the low-frequency content of the subjects' voices before feeding the delayed sound to the loudspeaker in the studio. The results of the experiment are shown in Fig. 5.

The effect of this bass-cut is seen to reduce the spread of the results and also makes the observers about 2 dB more tolerant of the delayed sound field in the studio (Fig. 5).

3.4. Discussion of Results

In all the experiments described, there is a consistent difference of about 8 dB between the results using the 180 millisecond delay corresponding to the 19 cm/second tape speed and those at the 90 millisecond (38 cm/second) delay; the former requires the greater insulation.

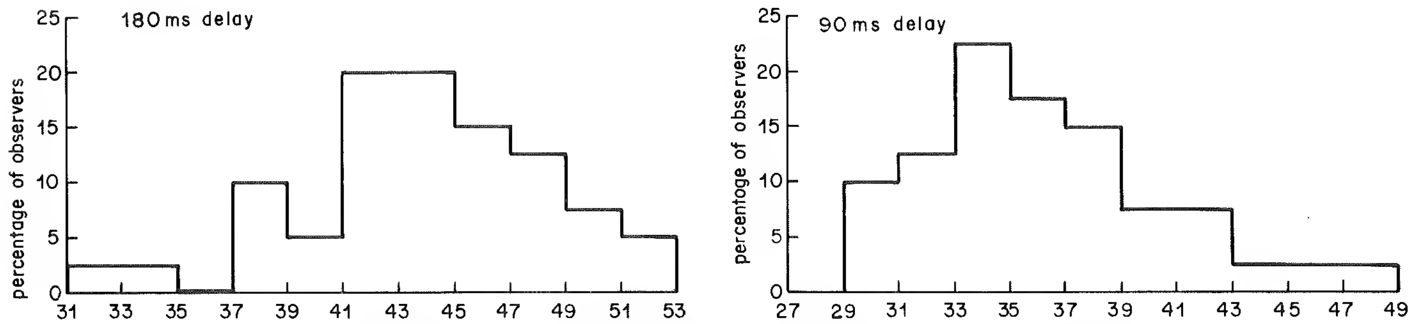


attenuation required at 500 Hz

Mean 42·1dB. Standard deviation 3·5dB

Mean 34·2dB. Standard deviation 4·2 dB

Fig. 3 - Results of single-wall simulation

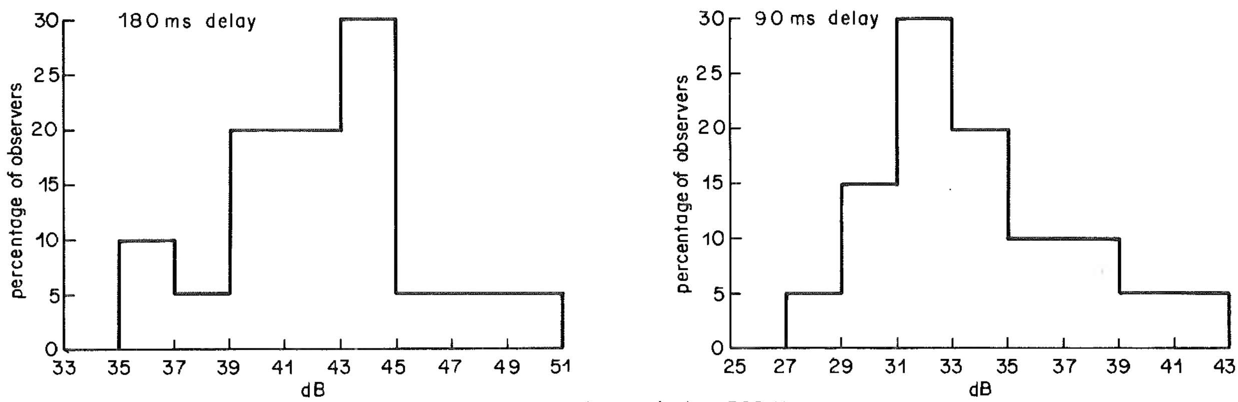


attenuation required at 500 Hz

Mean 43·4 dB. Standard deviation 4·5 dB

Mean 35·8 dB. Standard deviation 4·3dB

Fig. 4 - Results of double-wall simulation



attenuation required at 500 Hz

Mean 41·8 dB. Standard deviation 3·5 dB

Mean 33·3 dB. Standard deviation 3·5 dB

Fig. 5 - Results of double-wall simulation with bass-cut

The double-wall simulation requires about 1·5 dB more insulation at 500 Hz than the single-wall simulation. Statistical tests [1,2] on these distributions indicate that the probability of this difference arising by chance is about 1 in 3 (32%) for the 19 cm/second distributions and about 1 in 4 (24·6%) for the 38 cm/second distributions. It was thought possible that the relatively higher sound pressure level of the higher audio frequencies present in the delayed sound field in the single-wall simulation was more than offset by the relatively higher sound pressure level of the lower audio frequencies present in the double-wall simulation. Although taken alone these probabilities are, in themselves, not statistically significant, the results of the double-wall simulation with bass-cut constitute some additional evidence for this trend of thought. The removal of the bass content of the delayed sound fed back to the studio loudspeaker results in the subjects being approximately 2 dB more tolerant of the delayed sound. Statistical tests applied to the bass-cut data compared with the double-wall simulation data indicate a probability that these differences could arise by chance of about 1 in 4½ (22·2%) at a tape speed of 19 cm/second and only 1 in 18 (5·6%) at the 38 cm/second tape speed.

Also noteworthy is the reduction of the standard deviations of the distributions for the bass-cut experiment from the original value of about 4·5 dB to 3·5 dB. This is thought to be due to the elimination of the variation of bass content of different subjects' voices. A tentative conclusion is that, in these experiments, the higher frequency content (above 235 Hz) of the delayed sound field is 'masked' by the subject actually speaking, so rendering the lower audio frequencies relatively more important. In view of the somewhat low significances of the probabilities, a further experiment was carried out.

4. Confirmatory experiment

4.1. Experimental Details

This 'masking' effect could be eliminated by the use of recordings of the subjects' speech reproduced in the studio at the same sound pressure level at which they spoke in the experiments already described. Therefore a pair of loudspeakers giving a central image was used to reproduced a calibrated recording of each subject's speech. The delayed spectrum-shaped sound (double-wall simulation) was reproduced on a loudspeaker mid-way between the pair. Each subject was then asked to adjust an attenuator feeding the signal to the centre loudspeaker whilst listening to the recording of his own voice until he was just no longer aware of the delayed sound. The results are shown in Fig. 6.

4.2. Discussion of results of confirmatory experiment

This method of presentation gives very significantly different results from those obtained when 'live' speech is used. In the absence of 'masking' the subjects were, on average, 6·7 dB more tolerant at the 19 cm/second tape speed, and 5·7 dB more tolerant at the 38 cm/second tape speed. The statistical tests comparing the results in Fig. 6 with those in Fig. 4 indicate a probability of only ·002% that this difference could be due to chance. Moreover, comparing the individual results for each subject, the difference between a subject's result obtained in the double-wall simulation experiment and his result for the confirmatory experiment turns out to be positively correlated with the bass-content of his voice (measured by a Hewlett-Packard spectrum analyser). The coefficient of correlation was 0·51, a value in this case which could arise by chance with a probability of only 2% (1 in 50). It is therefore possible to summarise the probable mechanism of the situation in the following terms. When a subject hears a recording of his speech, together with the interfering delayed and spectrum-weighted signal superimposed, he perceives the resulting effect in that region of the audio spectrum in which his voice radiates the most energy (above 235 Hz); whereas when the primary source of sound is the subject himself speaking, these frequencies are 'masked' by his speech and he perceives the effect in that region of the spectrum which is transmitted most effectively by the sound-insulating partition, that is, in the bass frequencies.

5. Recommendations

Where a tape speed of 38 cm/second is used, these experiments indicate that a sound insulation between studio and cubicle of 43 dB at 500 Hz should prove satisfactory, but in areas where slower tape speeds are used, the insulation should be 8 dB more, namely 51 dB. These figures assume equal sound fields in studio and cubicle, but from measurements made in a recent survey it is usual for speech programmes at least, that the sound in the cubicle is monitored at a level some 6 dB higher than the original speech.

This matter will be included in a survey of sound pressure levels shortly to be published.[3]

Also these high insulation recommendations assume the typically encountered delays of 90 ms and 180 ms, which would be reduced if tape machines could be used with less physical separation between record and replay heads.

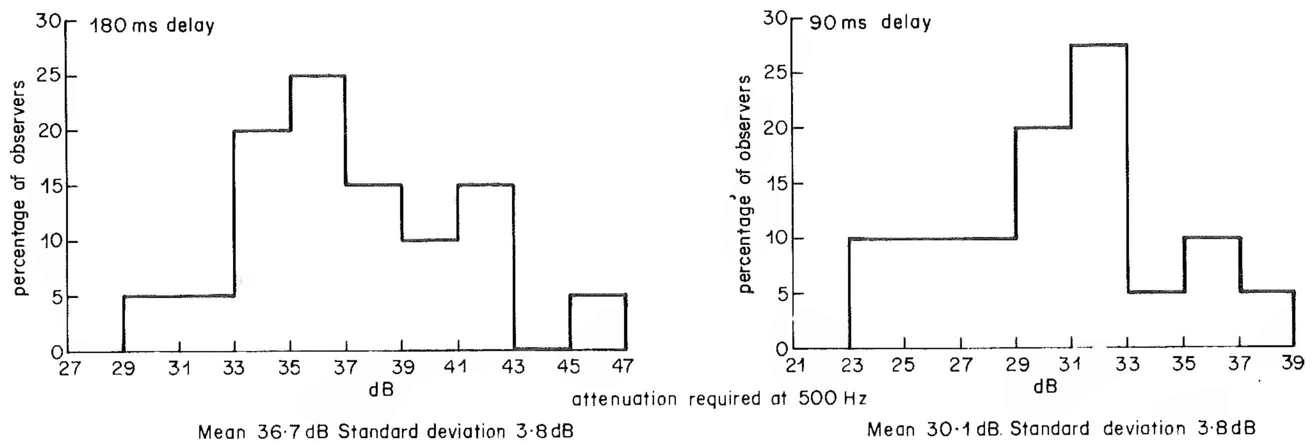


Fig. 6 - Results of confirmatory experiment

6. References

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3. Survey of sound pressure levels in BBC Studios (Research Department Report to be published).

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